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The U-space Concept

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The integration of civil unmanned aircraft systems (drones) into airspace has turned out to be a real challenge. Drones have difficulties in following many of the rules designed for manned aviation, because drones are plentiful and cheap, because they have no pilot on board, and because they are often flown at a very low altitude. This creates major issues relating to safety, traffic management, privacy, and law enforcement. To solve them, European regulatory bodies have come up with a new concept: U-space.

In this article, I focus on that particular concept. First, I explore several rules designed for manned aviation; second, I present several challenges posed thereto by drones; and third, I analyse how these challenges will be solved in U-space.

My analysis emphasizes that U-space is not merely a legal but also a technological concept, and it is as much a public as it is a private effort. I maintain that this interplay is necessary, since it is counterproductive to develop the concept without taking into account emerging technology and without close cooperation with the industry. My analysis also acknowledges that many U-space services are already available today. However, since many of such services are fragmentary and have only been demonstrated in a controlled environment, I argue that it will take much more effort to bring the concept to its full fruition.

1 INTRODUCTION

The established system of civil aviation,¹ in Europe and elsewhere,² is based on many international, regional, and national principles, rules, standards, and voluntarily adopted practices – in short, air law. This body of law has been adopted to advance safety and facilitate flying in both international and domestic aviation,³ in both commercial air transport and general aviation.⁴ Air law dictates that, for instance, aircraft in most cases

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¹ The present article excludes discussion on state aviation, including for instance aviation practiced by military, police, and customs services. See Convention on International Civil Aviation, Art. 3, para. b (Chicago Convention, 7 Dec. 1944), 15 U.N.T.S. 295; Ruwantissa Abeyratne, *Convention on International Civil Aviation: A Commentary*, 51–73 (Springer 2014).

² The present article only focuses on aviation practiced within and between states that follow aviation regulations adopted in the European Union, including the Member States of the Union as well as non-Member States associated with the European Aviation Safety Agency (EASA), including Iceland, Liechtenstein, Norway, and Switzerland.

³ For the purposes of this article, international aviation refers to aviation that crosses the borders of one state, whereas domestic aviation refers to aviation that remains within the borders of one state.

⁴ The former refers to the transport of passengers, cargo, or mail for compensation or hire, while the latter to other types of operation or aerial work. See e.g. Annex 6 to the Convention on International Civil Aviation: Operation of Aircraft – Part I: International Commercial Air Transport – Aeroplanes, Ch. 1 (9th. ed., as amended, ICAO 2010).

have to be type certified, registered, and maintained according to a programme. Their pilots need to undergo licensing, and commercial operators must be certified. Another principle is that airspace is divided into controlled and uncontrolled, and also into more specific classes. Additionally, regulations often set forth particular rules requiring the aircraft to communicate with air traffic control (ATC) and avoid other traffic. Aircraft must also be operated in accordance with either visual or instrument flight rules (VFR, IFR) and commonly at an altitude above 150 meters, apart from take-off and landing.⁵

Air law is based on a variety of instruments, the most fundamental being the Chicago Convention⁶ and standards and recommended practices (SARPs) developed by the International Civil Aviation Organization (ICAO). SARPs are, pursuant to Article 54(l) of the Chicago Convention, designated as Annexes to the Convention. Meanwhile, to complement SARPs, ICAO has also created procedures for air navigation services (PANS)⁷ and specialized guidance manuals. Voluntary practices have been developed by airlines, especially under the auspices of the International Air Transport Association (IATA). In the European Union, the matter is governed by several binding regulations issued by the European Commission (EC). These regulations have been drafted with the assistance of European Aviation Safety Agency (EASA), European Organization for the Safety of Air Navigation (Eurocontrol), and the Single European Sky ATM Research (SESAR) Joint Undertaking.

In recent years, however, the field of civil aviation has witnessed the rise of unmanned aircraft systems (UAS). These systems, which have no pilot on board the aircraft, are commonly known as drones.⁸ Through the cheapening and miniaturization of technology, among other factors, drones have turned from a tool of a few enthusiasts into a mainstream platform. The use of drones has escalated, and there is no sign of their popularity waning; quite the opposite. Studies indicate that the market will continue to expand in the coming years. Drone technology and its practical applications are still evolving rapidly.⁹

⁵ See below Ch. 2 for details about the given principles, rules, and standards.

⁶ *Supra* n. 1.

⁷ ICAO Doc 4444 – Procedures for Air Navigation Services: Air Traffic Management (16th ed., ICAO 2016). The Organization has also drafted several visionary documents about the management of air traffic, including e.g. ICAO Doc 9854 – Global Air Traffic Management Operational Concept (1st ed., ICAO 2005), and the regularly updated ICAO Doc 9750-AN/963 – Global Air Navigation Plan (5th ed., ICAO 2016).

⁸ On terminology, see my earlier contribution to this journal: *Unmanned, Remotely Piloted or Something Else? Analysing the Terminological Dogfight*, 42(3) Air & Space L. 349 (2017).

⁹ See e.g. European Drones Outlook Study: Unlocking the value for Europe (SESAR 2016). Drones have previously been discussed in this journal from a more general perspective by several authors. In a chronological order, see Anna Masutti, *Proposals for the Regulation of Unmanned Air Vehicle Use in Common Airspace*, 34(1) Air & Space L. 1 (2009); Stefan Kaiser, *UAVs and Their Integration into Non-Segregated Airspace*, 36(2) Air & Space L. 161 (2011); Sofia Michaelides-Mateou & Chrystel Erotokritou, *Flying into the Future with UAVs: The Jetstream 31 Flight*, 39(2) Air & Space L. 111 (2014); Jeremy Straub, Joe Vacek & John Nordlie, *Considering Regulation of Small Unmanned Aerial Systems in the United States*, 39(4/5) Air & Space L. 293 (2014); Ruwantissa Abeyaratne, *Remotely Piloted*

Drones create many challenges for air law, which has been designed chiefly for the purposes of manned aviation. First of all, many drones can be bought very cheaply and used safely without any training; indeed, the drone market ranges from toys to commercial systems. Second, there are so many UAS that the established air traffic management (ATM) infrastructure risks not having the means to manage all of them. Similarly, due to their small size and cheap retail price, most UAS are not designed to carry equipment like a transponder that would facilitate their safety among other aircraft. In addition, drones usually operate at a very low altitude. This is problematic because such airspace is often classified as uncontrolled but still contains the risk of the drone colliding with humans, structures, and other aircraft. Drones are also a potential hazard to privacy and security. Finally, by definition, there is no pilot on board the UAS, so drones face difficulties with the VFR/IFR distinction, and their capability to follow established avoidance procedures is also limited.¹⁰

To counter these issues, the European 2016 High Level Conference on Drones '[a]cknowledged the need for urgent action on the airspace dimension, in particular the development of the concept of "U-space" on access to low level airspace especially in urban areas'.¹¹ For this purpose, later that year, SESAR launched an exploratory call in the H2020 programme for innovative solutions to the development of Unmanned Traffic Management (UTM).¹² U-space has since been developed technologically by a number of private enterprises under the auspices of the Global UTM Association (GUTMA).¹³ Legally, the concept has been advanced in a number of documents, including for example EASA's 2017 proposal¹⁴ and 2018 opinion¹⁵ concerning the regulation of drones, SESAR's 2017 U-space blueprint¹⁶ and 2018 drone

Aircraft Systems: Some Unexplored Issues, 41(3) Air & Space L. 289 (2016); Ewen Macpherson, *Is the World Ready for Drones?*, 43(2) Air & Space L. 149 (2018).

¹⁰ See below Ch. 3 for details about the given challenges.

¹¹ Warsaw Declaration: 'Drones as a leverage for jobs and new business opportunities' (EASA 2016). Parallel developments not discussed here are taking place in the United States of America. See UAS Traffic Management (UTM) Research Transition Team (RTT) Plan (FAA 2017). Regarding National Aeronautics and Space Administration's (NASA) UTM research and development, see e.g. Parimal Kopardekar, *Unmanned Aerial System (UAS) Traffic Management (UTM): Enabling Low-Altitude Airspace and UAS Operations* (NASA 2014). Other projects also exist, including e.g. New York's UAS Secure Autonomous Flight Environment (U-SAFE), <https://nuairalliance.org/u-safe/> (accessed 20 Aug. 2018).

¹² See Call: Sesar 2020 Rpas Exploratory Research Call, <https://ec.europa.eu/research/participants/portal/desktop/en/opportunities/h2020/calls/h2020-sesar-2016-1.html> (accessed 19 June 2018).

¹³ See Global UTM Association, <https://gutma.org/> (accessed 14 Aug. 2018).

¹⁴ Notice of Proposed Amendment 2017-05 (A) and (B): Introduction of a regulatory framework for the operation of drones – Unmanned aircraft system operations in the open and specific category (EASA 2017).

¹⁵ Opinion No 01/2018: Introduction of a regulatory framework for the operation of unmanned aircraft systems in the 'open' and 'specific' categories (EASA 2018).

¹⁶ U-space Blueprint (SESAR 2017).

roadmap,¹⁷ the new EASA basic regulation adopted in 2018,¹⁸ and the Commission's draft regulations on drones.¹⁹ The Helsinki Declaration of 2017 called for the establishment of a European U-space demonstrator network,²⁰ and thus in 2018 SESAR launched a call for demonstrations²¹ which has been answered by several joint undertakings. U-space is a high priority project that is designed to be one of the key elements for the safe use of drones. Its first services are supposed to be available already in 2019.²²

What is the U-space concept about? How will it seek to solve the issues relating to the integration of drones into shared airspace? Will it offer feasible solutions, and when? This article seeks to explore the given questions. I begin answering them by detailing several principles, rules, and standards of established air law (Chapter 2). I discuss air law by chiefly referring to two sources: international air law, as included in the Chicago Convention and SARPs adopted by ICAO, and European Union air law, as set forth in regulations adopted by the institutions of the Union. Next, I elaborate on the challenges unmanned aviation poses to the established air law (Chapter 3) and describe the legal-technological solutions thereto presented by the U-space concept (Chapter 4). The fifth Chapter concludes the article.

2 RULES DESIGNED FOR MANNED AVIATION

2.1 CERTIFICATION, REGISTRATION, AND LICENSING

Air law begins from the standpoint that aircraft, as equipment, are certified in terms of airworthiness, and that operators are certified and pilots licensed. In international aviation, these obligations derive from the Chicago Convention. According to Article 31 of the Convention, every aircraft engaged in international aviation must bear its nationality and registration marks,²³ which implies²⁴ an obligation to register aircraft. Meanwhile, it is explicitly stated that such aircraft must be provided with a certificate of

¹⁷ European ATM Master Plan: Roadmap for the safe integration of drones into all classes of airspace (SESAR 2018).

¹⁸ Regulation (EU) 2018/1139 of the European Parliament and of the Council. On the effects of the new regulation on e.g. German air law on drones, see Malte Krumm, *Der neue europäische Rechtsrahmen für unbemannte Luftfahrzeuge – Anpassungsbedarf im deutschen Luftverkehrsrecht?*, Europäische Zeitschrift für Wirtschaftsrecht (2019, forthcoming).

¹⁹ Draft Commission Regulation (EU) laying down rules and procedures for the operation of unmanned aircraft, Preamble, para. 1 (EC 2018); Draft Commission Delegated Regulation (EU) on making available on the market of unmanned aircraft intended for use in the 'open' category and on third-country UAS operators (EC 2018).

²⁰ Drones Helsinki Declaration, Ch. 3, para. 2 (Trafi and EASA 2017).

²¹ See Call CEF-SESAR-2018-1 U-space (SESAR 2018).

²² Drone Roadmap, *supra* n. 17, at 12.

²³ Chicago Convention, *supra* n. 1, Art. 20. See also Annex 7 to the Convention on International Civil Aviation: Aircraft Nationality and Registration Marks (6th ed. as amended, ICAO 2012).

²⁴ Abeyaratne, *supra* n. 1, at 260.

airworthiness (CofA).²⁵ Operators that provide commercial air services internationally must also hold a certificate,²⁶ and pilots engaged in any type of international aviation are subject to general certification and licensing as well as type specific ratings.²⁷

The same obligations apply, to a great extent, to all aviation – domestic and international – in the EU. Aircraft must be registered²⁸ and certified in terms of initial and continuing airworthiness. The former is known as type certification, whereas the latter consists of the CofA as well as the yearly airworthiness review certificate.²⁹ Accordingly, aircraft operators must undergo certification³⁰ and pilots training to receive licensing and ratings.³¹ EU air law also requires commercial air transport operators to hold a distinct operating licence.³² Pursuant to national law, changes in the information about or the ownership of the aircraft must be notified to the national aviation authority of the state where the aircraft is registered.³³

It is no wonder that such requirements exist. One cannot simply build or purchase a manned aircraft from a convenience store and take off, since such vehicles are very difficult for laymen to fly, and because they pose a major risk to the environment. Another factor is the cost of manned aviation: at cheapest, even a (powered) ultralight aircraft – the cheapest and easiest aircraft to operate – costs several thousand euros³⁴ and an airplane some EUR 15,000,³⁵ which limits the amount of air traffic that needs managing. An aircraft is a long term investment, since many models can operate safely for several decades.³⁶ Hence, manned aircraft

²⁵ Chicago Convention, *supra* n. 1, Art. 31. See in detail Annex 8 to the Convention on International Civil Aviation: Airworthiness of Aircraft (11th ed. as amended, ICAO 2010); ICAO Doc 9760 – AN/967: Airworthiness Manual (3rd ed., ICAO 2014). See generally Filippo de Florio, *Airworthiness: An Introduction to Aircraft Certification and Operations* (Butterworth-Heinemann 2016).

²⁶ Annex 6 – Part I, *supra* n. 4, subs. 4.2.1.

²⁷ Chicago Convention, *supra* n. 1, Art. 32(a). See in detail Annex 1 to the Convention on International Civil Aviation: Personnel Licensing (11th ed. as amended, ICAO 2011).

²⁸ Regulation (EC) No 1008/2008 of the European Parliament and of the Council, Art. 12 (Note, however, that this obligation to register only applies to commercial air transport operators. Otherwise, within the EU, the obligation to register an aircraft is based on domestic legislation. See e.g. the United Kingdom's Air Navigation Order 2016, SI 2016/765 Art. 24).

²⁹ Regulation 2018/1139, *supra* n. 18, Arts 9–14 and Annex II. See in detail Commission Regulation (EU) No 748/2012; Commission Regulation (EU) No 69/2014; Commission Regulation (EU) No 1321/2014. Note, however, that the airworthiness certification of some aircraft is still based on the domestic legislation of each EU Member State.

³⁰ Regulation 2018/1139, *supra* n. 18, Arts 29–30 and Annex V. See in detail Commission Regulation (EU) No 965/2012 as amended.

³¹ Regulation 2018/1139, *supra* n. 18, Arts 20–21 and Annex IV. See in detail Commission Regulation (EU) No 1178/2011.

³² Regulation 1008/2008 *supra* n. 31, Art. 3.

³³ E.g. UK ANO, *supra* n. 31, Art. 28.

³⁴ E.g. a Scout paramotor costs some EUR 6,000. See <http://www.scoutparamotor.com/scout-prices/> (accessed 9 July 2018).

³⁵ See e.g. 10 Cheapest Planes in the Sky, <https://www.planeandpilotmag.com/article/10-cheapest-birds-in-the-sky/> (accessed 5 July 2018).

³⁶ See e.g. Commercial aircraft fleet by age of aircraft, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=avia_eq_arc_age&lang=en (accessed 6 Aug. 2018).

are subjected to lengthy and demanding procedures, ensuring that aviators and their equipment follow relevant standards.

2.2 CLASSIFICATION OF AIRSPACE

Air law classifies airspace in several ways. The Chicago Convention recognizes the sovereignty of each state over the airspace above its territory, including land areas and territorial waters.³⁷ This constitutes national airspace, as opposed to international airspace. The latter is located above the areas outside the land territories and territorial waters of states.

Another classification, which is more relevant to this article, is the one between controlled and uncontrolled airspace. Controlled airspace refers to airspace where ATC services are provided, usually including airspace surrounding aerodromes and high altitude corridors where commercial aircraft fly most of their flight. It usually consists of – depending on the nomenclature used in a particular state – a controlled traffic region (CTR), terminal control area (TCA), and control area (CTA). It is specifically classified into Classes A–E. Meanwhile, in uncontrolled airspace that consists of Classes F and G, no ATC services are provided. Such airspace usually exists away from aerodromes and at low altitudes.³⁸ Besides this classification, there are also areas where civil aviation is restricted or prohibited altogether.³⁹

The principle is that air traffic falls generally along the given lines. Flying in controlled airspace is provided with guidance, and flying in uncontrolled airspace is left on its own devices or provided with minimal service. Flights that take place in Class A–C airspace, in particular, are subject to several guidance measures. Prior to entering into and while in such airspace, every flight must obtain ATC clearances: messages that authorize the aircraft to fly in a particular way. Additionally, the aircraft must issue position reports when passing reporting points, at prescribed intervals, or when requested by the ATS unit. In controlled airspace, IFR flights (and in some cases VFR flights) are separated from each other both vertically and horizontally, pursuant to the requirements set by the Class of airspace. These requirements are applied in international aviation,⁴⁰ as well as within the EU.⁴¹

³⁷ Chicago Convention, *supra* n. 1, Arts 1–2. The use of *outer space* (not discussed here) is regulated by other documents, inter alia, the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space (Outer Space Treaty, 27 Jan. 1967), 610 U.N.T.S. 205. See e.g. Bin Cheng, *Studies in International Space Law*, Ch. 3 and Ch. 14 (Clarendon Press 1997).

³⁸ See Annex 11 to the Convention on International Civil Aviation: Air Traffic Services, Ch. 1, s. 2.6, and app. 4 (13th ed. as amended, ICAO 2001); Commission Implementing Regulation (EU) No 923/2012, SERA.6001.

³⁹ Chicago Convention, *supra* n. 1, Art. 9.

⁴⁰ Annex 2 to the Convention on International Civil Aviation: Rules of the Air, Ch. 1 and subss 3.6.1 and 3.6.3 (10th ed. as amended, ICAO 2005); Annex 11, *supra* n. 38, paras 3.3.4–3.3.5.

⁴¹ Regulation 923/2012, *supra* n. 38, SERA.6001, 8015, and 8025.

2.3 COMMUNICATION AND SURVEILLANCE

Air law also extends to the technical measures by which air traffic is managed. One rudimentary measure is the flight plan, detailing the projected operation to be undertaken by the aircraft. According to the standards adopted by ICAO, such a plan must be filed prior to, *inter alia*, any flight that is international, or that is to be provided with ATC service.⁴² Flight rules adopted in the EU contain the same obligation, and also require a plan for any night time flight that leaves the vicinity of an aerodrome.⁴³

Another obvious measure is communication between the aircraft and the ground station ATC, which first includes radiotelephony and/or data link.⁴⁴ In international operations, ICAO requires nearly every aircraft to be provided with radio communication equipment.⁴⁵ Similarly in the EU, regulations mandate the use of radios in almost all cases, the particular requirement depending on the type of aircraft and the nature and location of the operation.⁴⁶ Conversely, again in the EU, the aircraft, the pilot, the ground station, and the air traffic controller must all hold a licence to operate their radio: one cannot transmit without permission.⁴⁷

Besides such equipment, aircraft operating internationally, unless exempted, must carry a transponder⁴⁸ regardless of the type of operation.⁴⁹ Aircraft exceeding a particular weight threshold and carrying many passengers not only have to be equipped with a transponder but also an airborne collision avoidance system (ACAS).⁵⁰ There are several collision avoidance systems, including for example passive (PCAS) and flight alarm (FLARM), but currently only the traffic alert and

⁴² Annex 2, *supra* n. 40, para. 3.3.1.2. See also ICAO Doc 4444, *supra* n. 7, s. 4.4.

⁴³ Regulation 923/2012, *supra* n. 38, SERA.4001.

⁴⁴ Annex 11, *supra* n. 38, para. 6.1.1.1.

⁴⁵ Annex 6 – Part I, *supra* n. 4, para. 7.1.1; Annex 6 to the Convention on International Civil Aviation: Operation of Aircraft – Part II: International General Aviation – Aeroplanes, paras 2.5.1.1–2.5.1.4 (8th ed., ICAO 2014). The only exemptions to this are non-commercial flights operated pursuant to visual flight rules in class E, F, and G airspace. See the table in Annex 11, *supra* n. 38, Appendix 4.

⁴⁶ Commission Regulation (EU) No 965/2012 as amended, CAT.IDE.A.330 *et seq.*

⁴⁷ The licensing requirement stems from International Telecommunication Union Radio Regulations, Art. 18 (as amended, ITU 2016). See also e.g. Annex 1, *supra* n. 30; Chicago Convention, *supra* n. 1, Art. 30; and national legislation, e.g. UK ANO, *supra* n. 31, Arts 202–203. EASA does not regulate radiotelephony licences.

⁴⁸ Transponders operate by using different communication protocols, known as modes, of which three are used in civil aviation: A, C, (usually together as mode A/C) and S. The performance standards of these devices are elaborated on in e.g. Annex 10 to the Convention on International Civil Aviation: Aeronautical Telecommunications – Volume IV: Surveillance and Collision Avoidance Systems (5th ed., ICAO 2014). For the purposes of this article, it is not necessary to discuss in detail the meaning of these modes nor the required mode for particular airspace. See generally e.g. *Transponders in aviation*, 19 NETALERT newsletter (Eurocontrol 2014).

⁴⁹ Annex 6 – Part I, *supra* n. 4, s. 6.19; Annex 6 – Part II, *supra* n. 45, s. 2.4.13. See also Annex 11, *supra* n. 38, para. 2.26.

⁵⁰ Annex 6 – Part I, *supra* n. 4, s. 6.18; Annex 6 – Part II, *supra* n. 45, s. 3.6.9. The purpose of ACAS is to warn the pilot of each aircraft if they are on a collision course and provide a trajectory that will avoid

collision avoidance system (TCAS) meets the ICAO standards.⁵¹ When it comes to domestic aviation within the EU, similar requirements apply, though again depending on the nature and location of the operation and the type of aircraft. Broadly speaking, transponders are mandatory for aircraft exceeding certain thresholds or seeking to fly in controlled airspace following IFR.⁵²

Air law imposes on states a general obligation to facilitate and expedite aviation.⁵³ This obligation is supplemented by the ICAO recommendation to provide appropriate and sufficient air services in terms of safety and capacity.⁵⁴ To meet such requirements and to maximize airspace use while maintaining safety standards, states have adopted various radar surveillance systems. These include, first, the primary surveillance radar (PSR), which detects the distance and heading of any flying object within its reach. A more elaborate instrument is the secondary surveillance radar (SSR) that provides information about the altitude and identity of the aircraft, given that the aircraft is equipped with a transponder. Technical solutions also include multilateration (the use of several beacons to receive transponder signals) and automatic dependent surveillance-broadcast (ADS-B), where satellites are used to determine the position of the aircraft.⁵⁵

2.4 FLIGHT RULES

One key principle of air law is that each aircraft must follow either of the two types of flying rules that are employed in manned aviation: visual flight rules (VFR) or instrument flight rules (IFR). Roughly speaking, when operating under VFR, navigation is based on the eyesight of the pilot(s). Hence, VFR flights must be conducted so that the pilot has certain minimum visibility and distance from clouds. When operating under IFR, on the other hand, navigation is based on the instruments of the aircraft. This means that the aircraft must be equipped with suitable instruments and navigation equipment, and maintain communication with the ground.⁵⁶

Flight rules, which originate from ICAO SARPs, position manned air traffic above a certain minimum altitude, except when necessary for take-off and landing or when permitted by the appropriate authority. Pursuant to VFR, an aircraft must

the collision. See generally e.g. ACAS Guide: Airborne Collision Avoidance (3.0 ed., Eurocontrol 2017).

⁵¹ Annex 10, *supra* n. 48, Ch. 4, n. 3.

⁵² Commission Regulation (EU) No 1332/2011, Art. 3 and Annex; Commission Regulation (EU) No 965/2012 as amended, CAT.IDE.A.350 *et seq.*

⁵³ Chicago Convention, *supra* n. 1, Arts 22 and 28.

⁵⁴ ICAO Doc 4444, *supra* n. 7, paras 2.1.1 and 3.1.1.1.

⁵⁵ See e.g. European ATM Master Plan (SESAR 2015).

⁵⁶ See Annex 2, *supra* n. 40, para. 2.2, Ch. 4, and Ch. 5; Regulation 923/2012, *supra* n. 38, SERA.2005.

not fly below 150 meters above ground or water; over populated areas or open-air assemblies the minimum altitude is 300 meters. IFR flights must always take place 300 meters above the highest obstacle within eight kilometres of the aircraft. The minimum altitude is 600 meters when flying over high terrain or mountainous areas.⁵⁷

In some cases, of course, manned aircraft are allowed to fly at low altitudes. Flying low may be allowed at, for example, near accident sites, as well as when conducting specialized operations like aerial photography or when training pilots. However, most routes (corridors of controlled airspace) for commercial manned aviation are located at a very high altitude. This is because flying high promotes safety, reduces noise, and saves fuel.⁵⁸

3 UNMANNED CHALLENGES

3.1 QUANTITY, LIFE CYCLE, AND SIMPLICITY

Unmanned aircraft systems have serious difficulties in following many of the aforementioned principles and rules. This is partly because the current drone market is, in terms of quantity, dominated by toy and hobby rather than professional or commercial drones,⁵⁹ though the latter are becoming more popular.⁶⁰ In contrast with manned aircraft, there is often little to no financial threshold to operate a drone. A cheap toy model costs, at the time of writing this, only around EUR 15.⁶¹ Even equipment falling within the professional market segment is affordable, ranging from EUR 400 upwards.⁶² Such drones, being inexpensive and not very durable, are sold in large quantities – millions every year in Europe alone.⁶³ Only drones used for commercial purposes are clearly out of the reach of consumers, costing some EUR 10,000 or more.⁶⁴ In accordance with their low price, the typical lifespan of a UAS is circa thirty months.⁶⁵

⁵⁷ Annex 2, *supra* n. 40, paras 4.6 and 5.1.2; Regulation 923/2012, *supra* n. 38, SERA.5005 and 5015.

⁵⁸ See e.g. Hugh Morris, *Why planes fly at 35,000 feet: The reason for high altitude flights*, <http://www.traveller.com.au/why-planes-fly-at-35000-feet-the-reason-for-high-altitude-flights-guxhc9> (accessed 13 July 2018).

⁵⁹ Of the classification, see Blanca de Miguel Molina & Marival Segarra Oña, *The Drone Sector in Europe*, in *Ethics and Civil Drones: European Policies and Proposals for the Industry*, Table 2 (María de Miguel Molina & Virginia Santamarina Campos eds, Springer 2018).

⁶⁰ Outlook Study, *supra* n. 9, at 14–36. See also NPA 2017–05 (B), *supra* n. 14, at 8–12.

⁶¹ See e.g. zoopa Q 55 zepto, <https://acme-online.de/en/rc-models/multicopter/zoopa-q55-zepto.html> (accessed 11 July 2018).

⁶² See e.g. Parrot Bebop 2, <https://www.parrot.com/us/drones/parrot-bebop-2#parrot-bebop-2-details> (accessed 11 July 2018).

⁶³ Outlook Study, *supra* n. 9, at 17.

⁶⁴ See e.g. Altura Zenith, <https://www.aerialtronics.com/en/drone-solution-bundles#bundle> (accessed 3 Aug. 2018).

⁶⁵ NPA 2017–05 (B), *supra* n. 14, at 47.

Due to the large quantity, low cost, relatively short life cycle, and small size of UAS, certifying their airworthiness and registering them through the same procedure as manned aircraft does not make sense. Such an undertaking would be burdensome and perhaps impossible for aviation authorities. It would require spending a lot of time and effort for each type and piece of equipment that is often inexpensive and might only be on the market for a year or two. A single drone is sometimes only used for a short time period before being damaged beyond repair. Selling a drone to another person or scrapping it would also require notifying the national aviation authority, which would increase the initial workload. Meanwhile, tiny registration marks on a small drone would not help its identification at all.⁶⁶

A similar argument goes for the licensing of pilots and certification of operators. Whereas manned aircraft must, in Europe, always be operated by pilots with some training, many toy, hobby, and even professional UAS can be operated by laymen with no training. Indeed, due to technological developments, the operation of drones has become very easy.⁶⁷ They are simple enough that flying lessons are not necessary to begin operation. Hence, it does not seem sensible to require *all* drone pilots and operators to undergo licensing and certification. To call for all drone pilots to take lengthy and mandatory training courses and all operators to uphold safety management systems would simply be too much.

Yet, it seems that foregoing the given requirements is not a good solution either. While instruction is not necessary to begin flying a drone, it may be necessary to fly the drone *safely*. Pursuant to a survey done by one retailer in the United Kingdom (UK), virtually all drone users are aware of operating rules.⁶⁸ However, even if this is the case, safety hardly seems guaranteed. Being aware of regulations is different than actually understanding and, even more so, following them. Thus, reckless pilots risk violating privacy, entering into prohibited airspace, and harming people both on board other aircraft and on the ground. Of course, drones can also be used for illegal purposes. Together with the inability to identify drones, this is a troublesome combination. Without registration, there is no identification. In other words, there is not much way of knowing who is conducting operations and with what equipment: by default, a drone is not linked to the buyer when purchased. Enforcing laws upon drones is therefore a difficult task. Finally, if no airworthiness

⁶⁶ Many such issues were identified in the US in 2015, when the FAA required all drone operators to register. See e.g. Jonathan Rupprecht, *11 Big Problems with the FAA's Mandatory Drone Registration*, <https://jrupprechtlaw.com/the-problems-with-mandatory-drone-registration> (accessed 17 Aug. 2018).

⁶⁷ E.g. Scott Gilbertson, *Why It's Never Been Easier to Fly a Drone*, <https://www.wired.com/2015/12/drones-easy-to-fly/> (accessed 9 July 2018). See also NPA 2017-05 (B), *supra* n. 14, at 26-27.

⁶⁸ The UK Drone Users Report, 14 (Drones Direct 2016).

standards in terms of technical specifications are imposed on the drone, the system might not be safe or interoperable with other systems.⁶⁹

3.2 OPERATIONAL DIFFERENCES

A different problem is that the operation of UAS does not really fit the categorization of air traffic into controlled and uncontrolled. Why this is the case requires a bit of explaining. First of all, it is burdensome for all drone operators to comply with the requirements of controlled airspace. UAS are not usually sold with radio equipment to listen to or practice air traffic communication, such as clearances and emergency warnings. And, even if the operator acquires such equipment, they will have to qualify for radio communication and apply for a licence. Yet it seems unclear which licence a UAS operator must apply for, the usual choice being between a licence to operate a radio on board the aircraft and a ground station licence to communicate with other aircraft.⁷⁰ Neither seems to suit drone operators who would need a licence to operate a mobile ground station that communicates with ATC.

Even if an operator manages to acquire a suitable licence, their drone may be too small and slow, and fly at an altitude too low to be noticed by the primary radar and thus be guided by ATC. Distinguishing a drone from a bird is also challenging, and in some cases radar filters are applied to reduce clutter caused by small flying objects. Hence, a new approach would be needed to detect and classify drones.⁷¹ Meanwhile, the secondary radar will not detect the drone unless it has a transponder. To meet this requirement is a major hurdle, since transponders are very expensive in comparison to the price of many drones, and are virtually always designed for manned aircraft in terms of size and connectivity.⁷² Finally, drones, especially rotary wing ones, can take off and land pretty much anywhere, so they are not bound to operate from an aerodrome like many manned aircraft.

The given factors push UAS to operate in uncontrolled airspace. Yet, the operation of UAS in uncontrolled airspace differs from the operation of

⁶⁹ NPA 2017-05 (B), *supra* n. 14, at 24 and 31–49; UAS Safety Risk Portfolio and Analysis (EASA 2016). See also e.g. Conner Forest, *17 Drone Disasters that Show Why the FAA Hates Drones*, <https://www.techrepublic.com/article/12-drone-disasters-that-show-why-the-faa-hates-drones/> (accessed 7 Aug. 2018); EASA Annual Safety Review 2017, 90–94 (EASA 2017).

⁷⁰ See above.

⁷¹ See e.g. Radar detection and classification of small UAVs and micro-drones, https://www.gla.ac.uk/media/media_480052_en.pdf (accessed 12 July 2018).

⁷² Small scale transponders for UAS like the Uavionix Ping200S do exist, but they cost some EUR 3,000. See <https://www.uavionix.com/products/ping200s/> (accessed 12 July 2018). Even an ADS-B receiver, the cheapest solution offered by the same firm, costs around EUR 250. See <https://www.uavionix.com/products/pingrx/> (accessed 12 July 2018).

manned aircraft therein. This is because, as mentioned, drones are usually flown at a very low level (VLL), ranging from a few to a few hundred meters.⁷³ Indeed, in many European countries, their operation has already been restricted so that they must be flown at around 120 or 150 meters at highest,⁷⁴ putting them below most, although not all, manned air traffic. After all, both VFR and IFR are tailored for manned aircraft,⁷⁵ setting the minimum flying altitude at 150–300 metres.

The problem with drones operating in VLL airspace is that, at low altitudes, there are several important interests that require safeguarding. These interests include, for example, industrial and business activities, and the privacy, safety, and property of natural persons. Especially the urban environment is risky, as drones may collide with each other and with people. This creates a dilemma: drones operating in uncontrolled airspace should be controlled, including separation from fixed and moving objects, each other, and manned aircraft. Yet the current regime lacks any such means of control.⁷⁶

A challenge that affects drone operation regardless of location is that the drone pilot is not on board the aircraft but on the ground. The main problem with this is that drone operations can also take place beyond the visual line of sight of the pilot (BVLOS), as opposed to within (VLOS).⁷⁷ When flying BVLOS, the pilot's reading of the situation is obviously limited, so they cannot detect external dangers directly. This makes the avoidance of collisions a difficult task, since in the vast majority of cases there is no ATC to guide the drone. Yet precisely being able to operate BVLOS is 'critical for many ... operations to be economically viable'.⁷⁸ This suggests that BVLOS rules and capability should be developed, and that flight rules should distinguish between VLOS and BVLOS operations, rather than between VFR and IFR operations.

4 U-SPACE

4.1 THE NATURE OF THE CONCEPT

The most pressing challenges with UAS might be solved by establishing a distinctive area, zone, or class of airspace to suit their operational needs. Yet U-space,

⁷³ NPA 2017-05 (B), *supra* n. 14, at 40; Drone Roadmap, *supra* n. 17, at 4. See generally e.g. Joseph Flynt, *How high can you fly a drone?*, <http://3dinsider.com/drone-altitude/> (accessed 13 July 2018).

⁷⁴ Outlook Study, *supra* n. 9, at 80–90.

⁷⁵ NPA 2017-05 (B), *supra* n. 14, at 40.

⁷⁶ *Ibid.*, at 24 and 39–43.

⁷⁷ See generally e.g. ICAO Doc 10019 – AN/507: Manual on Remotely Piloted Aircraft Systems (RPAS), s. 9.5 (ICAO 2015).

⁷⁸ Outlook Study, *supra* n. 9, at 10.

regardless of its name, does not seek to disturb the preceding segmentation of airspace: it is not a new volume of space at all. It is not designed to exist alongside outer space and airspace, nor alongside Classes A–G of airspace as ‘Class U’ airspace.⁷⁹ This seems confusing enough. After all, why call it a space if it is not one? Would not the term unmanned traffic management (UTM) be more fitting?

The ‘space’ in U-space does, however, make certain sense. It signifies that all airspace ought to become viable for UAS. The idea is to facilitate the access of drones, with proper qualifications, into pre-existing segments. After all, one of the principles of U-space is to leverage existing aeronautical infrastructure as much as possible. The U-space concept does not, however, attempt to interfere with the regime already in place for manned aircraft. Rather, U-space is meant to enhance all airspace with a collection of new services and procedures. Regardless, the establishment of such services and procedures may lead to updates and new training requirements for existing systems and personnel.⁸⁰

It is important to point out that U-space is not a top-down regulatory project. Instead, it is a collaboration between the public and private sectors. Many stakeholders are involved in the development of the concept in Europe: EASA, Eurocontrol, SESAR, GUTMA, national aviation authorities, private entities creating software and hardware, and drone operators as the end users. Hence, in many ways, U-space is already emerging in products by companies such as AirMap,⁸¹ Skyward,⁸² and Unifly.⁸³ These companies, as described below, are creating, demonstrating, and launching the very services the concept is about, both for the existing ATM infrastructure and drone operators. This process could be described as one of co-regulation.⁸⁴

The U-space concept is part of the general development of the European regulatory framework on drones. Most importantly, it is linked to the risk-based and performance-driven approach,⁸⁵ the idea that UAS ‘operations should be regulated based on the nature and risk of the operation or activity.’⁸⁶ Pursuant to this approach, European regulatory bodies have at least since 2015 classified

⁷⁹ U-space Blueprint, *supra* n. 16, at 2. See also Drone Roadmap, *supra* n. 17, at 10.

⁸⁰ U-space Blueprint, *supra* n. 16, at 2–3. See also Drone Roadmap, *supra* n. 17, at 10; NPA 2017–05 (A), *supra* n. 14, at 12; NPA 2017–05 (B), *supra* n. 14, at 41–42. In targeting all airspace, U-space enacts one of the conceptual changes envisioned in ICAO’s global ATM concept: that all airspace will be a usable resource. See ICAO Doc 9854, *supra* n. 7, para. 2.1.2, subpara. a.

⁸¹ See AirMap, <https://www.airmap.com/> (accessed 14 Aug. 2018).

⁸² See Skyward, <https://skyward.io/> (accessed 14 Aug. 2018).

⁸³ See Unifly, <https://www.unifly.aero/> (accessed 14 Aug. 2018).

⁸⁴ See María de Miguel Molina & María Ángeles Carabal Montagud, *Legal and Ethical Recommendations*, in *Ethics and Civil Drones: European Policies and Proposals for the Industry*, 78 (María de Miguel Molina & Virginia Santamarina Campos eds, Springer 2018).

⁸⁵ U-space Blueprint, *supra* n. 16, at 3.

⁸⁶ Draft Regulation on operation, *supra* n. 19, Preamble, para. 1.

drone operations into three categories, from the lowest to the highest risk: open, specific, and certified. The open category will be regulated through limitations, operational rules, pilot competencies, and drone product legislation; the specified category through risk assessment and authorization of the operation; and the certified category through requirements similar to manned aircraft.⁸⁷ The services of U-space are utilized with regard to these categories, providing flexibility.⁸⁸

4.2 FUNDAMENTAL SERVICES

As discussed above, registering all UAS by regular means would be undesirable, but not registering them at all would also be problematic in terms of safety. Hence, the U-space concept seeks to combine law and emerging technology to enable a simpler registration process in the form of electronic registration. This e-registration of the operator and, in some cases, the UA itself, constitutes one of the fundamental (foundation, U1) services of U-space.⁸⁹

Pursuant to the new EASA basic regulation adopted in June 2018,⁹⁰ an operator must register itself and its drones when operating in the certified category. In that category, drones will also be type certified and issued a CofA. In the open and specific categories, when using an uncertified drone, only the operator must be registered. The latter obligation will trigger when operating a UA with an impact energy above 80 joules⁹¹ or when the operation presents risks to privacy, data protection, security, or the environment.⁹² Drones falling under the given threshold are considered so safe that registration (and thus integration into U-space) is not necessary. Electronic registration will serve as the basis of electronic identification, another fundamental (U1) component of U-space.⁹³

Electronic registration and identification are by no means wholly novel solutions. Some EU Member States have already established online drone registries that do not operate by normal means of aircraft registration but simply require operators to input some basic data about their aircraft and type of operation. In order to identify aircraft,

⁸⁷ Advance Notice of Proposed Amendment (A-NPA) 2015-10: Introduction of a Regulatory Framework for the Operation of Unmanned Aircraft (EASA 2015). See later chronologically in 'Prototype' Commission Regulation on Unmanned Aircraft Operations (EASA 2016); NPA 2017-05 (A) and (B), *supra* n. 14; Opinion No 01/2018, *supra* n. 15.

⁸⁸ See Drone Roadmap, *supra* n. 17, at 10; U-space Blueprint, *supra* n. 16, at 3.

⁸⁹ U-space Blueprint, *supra* n. 16, at 3-4. See also Drone Roadmap, *supra* n. 17, at 11 and 26; NPA 2017-05 (B), *supra* n. 14, at 42.

⁹⁰ Regulation 2018/1139, *supra* n. 18.

⁹¹ *Contra* the drafts of the implementing regulations, which utilize a threshold of maximum take-off mass of 250 grams and over. In Opinion No 01/2018, *supra* n. 15, para. 2.4.3.1., it is noted that the two values correspond with each other; yet, the deviation is not explained in any way.

⁹² Regulation 2018/1139, *supra* n. 18, Arts 56-57 and Annex IX, paras 4.1-4.2.

⁹³ U-space Blueprint, *supra* n. 16, at 4. See also Drone Roadmap, *supra* n. 17, at 11 and 26; NPA 2017-05 (B), *supra* n. 14, at 42.

states have required drones to be equipped with an identification plate, containing some basic information about the operator.⁹⁴ The problem with established national registers is, though, that they are fragmentary and isolated, lacking interoperability with each other and with, for example, identification and flight planning systems. Meanwhile, the problem with fixed ID plates is that, being a low-tech solution, there is no way of identifying a drone without seeing the aircraft up close.

In U-space, these problems will be solved by ensuring that drone registers are digital and interoperable, and also accessible in real time – as required by the draft regulation on drone operations in open and specific categories.⁹⁵ Interoperable authentication and verification will be possible with solutions like AirMap's Registry Engine.⁹⁶ The way this works is that drones ought to allow the operator to insert their registration number. During the operation, then, the number must be provided in real time as electronic data. In other words, UAS must be equipped with a system transmitting the identity of the aircraft. Yet, electronic identification pursuant to current drafts should not only provide the identity of the drone, but also its geographical position, height, take off point, and associated time.⁹⁷

This requirement leads to the final fundamental (U1) U-space service: geofencing. Geofencing refers to technology by which virtual boundaries for flying are defined, utilizing a global navigation satellite system (GNSS) like the global positioning system (GPS) or European Union's Galileo.⁹⁸ Also known as geo-awareness, the purpose of geofencing is to load data on airspace limitations and warn operators of possible breaches of such limitations. Such capability is planned as obligatory for all drones with a maximum take-off mass (MTOM) of over 250 grams. The standards emphasize flight safety: when limiting access to certain airspace, the system must not endanger the safe operation of the aircraft.⁹⁹

⁹⁴ See NPA 2017-05 (B), *supra* n. 14, at 47; Outlook Study, *supra* n. 9, at 80–90. E.g. this has been the case since 2015 in my home country (Finland), where the use of UAS has been subject to notifying the national aviation authority and carrying the name and contact details of the operator. See OPS M1-32: Use of Remotely Piloted Aircraft and Model Aircraft (Trafi 2018), paras 3.1.2 and 3.1.8.

⁹⁵ Draft Regulation on operation, *supra* n. 19, Art. 3, para. 4 and Art. 7; Annex, UAS.OPEN.060 and UAS.SPEC.060. See also Regulation (EU) No 910/2014 of the European Parliament and of the Council.

⁹⁶ See Out-of-the-Box UTM, <https://www.airmap.com/utm/> (accessed 14 Aug. 2018).

⁹⁷ Draft Regulation on market, *supra* n. 19, Art. 2, para. 28; Appendix 2, para. 11; Appendix 3, para. 13; Appendix 4, para. 8; Appendix 6, paras 1 and 2 (EC 2018). See also Draft Regulation on operation, *supra* n. 19, Art. 2, para. 18; Annex, UAS.OPEN.020, UAS.OPEN.030, and UAS.OPEN.040; Drone Roadmap, *supra* n. 17, at 26.

⁹⁸ U-space Blueprint, *supra* n. 16, at 3–4. See also Drone Roadmap, *supra* n. 17, at 11 and 26; NPA 2017-05 (B), *supra* n. 14, at 42. For an extensive EASA study about geofencing, see EASA/NAA Task Force Report: Study and Recommendations regarding Unmanned Aircraft System Geo-Limitations (EASA 2016).

⁹⁹ Draft Regulation on market, *supra* n. 19, Art. 2, para. 29; Appendix 2, para. 12; Appendix 3, para. 14; Appendix 4, para. 9; Draft Regulation on operation, *supra* n. 19, Annex, UAS.OPEN.020, UAS.OPEN.030, and UAS.OPEN.040.

This legal-technological solution is aimed at preventing airspace violations. It seeks to circumvent several contributing factors, including the lack of extensive pilot training. Since not all drone pilots can be expected to know everything about airspace limitations and since some might disregard rules anyway, it is useful to include such capabilities in the drone itself. When the drone knows where it should not fly, the system is not as much relying on each pilot to check for notices issued by the air navigation service provider. Through geofencing, most UAS operators will not have to purchase radio equipment to communicate with ATC, and their aircraft will not have to be equipped with transponders. Accordingly, since restrictions are automatic, ATC need not micromanage every drone in order to prevent it from passing into prohibited or restricted airspace. Per the principles of U-space, the solution is scalable, cost-effective, and adaptable, and since it does not burden drone operators significantly, it also guarantees them fair access to airspace.¹⁰⁰

To be sure, geofencing is not a U-space invention. Air navigation service providers (ANSPs) like Deutsche Flugsicherung,¹⁰¹ aviation authorities like the Finnish Transport Safety Agency (Trafi),¹⁰² and UTM companies like Unifly¹⁰³ already offer digital map solutions that inform drone pilots about such restrictions. Furthermore, geofencing as a technology is already utilized by many UAS, including for example DJI drones with their geospatial environment online (GEO).¹⁰⁴ Hence, geofencing, too, puts into action the principle that U-space should leverage existing services, infrastructure, and technologies as much as possible.¹⁰⁵ Yet, the ultimate goal is to embed into U-space a standardized system of flight restrictions across the European Union and across different drone manufacturers. Furthermore, the information provided in U-space to the operator is aimed at being verifiably valid, coming from accredited sources. Another objective is to make the system compatible with other U-space services.¹⁰⁶

4.3 INITIAL SERVICES

Geofencing included in the first phase of U-space will likely include just pre-tactical geofencing, that is, information (restrictions and notices to airmen

¹⁰⁰ U-space Blueprint, *supra* n. 16, at 3.

¹⁰¹ See DFS drone app, https://www.dfs.de/dfs_homepage/en/Drone%20flight/Rules%20and%20regulations/DFS%20drone%20app/ (accessed 15 Aug. 2018).

¹⁰² See Droneinfo, <https://www.droneinfo.fi/en> (accessed 16 Aug. 2018).

¹⁰³ See The Map, <https://www.unifly.aero/user-tools-map> (accessed 14 Aug. 2018).

¹⁰⁴ See Fly Safe Geo Zone Map, <https://www.dji.com/flysafe/geo-map> (accessed 10 Aug. 2018).

¹⁰⁵ U-space Blueprint, *supra* n. 16, at 3.

¹⁰⁶ Drone Roadmap, *supra* n. 17, at 26–27; NPA 2017–05 (B), *supra* n. 14, at 33.

(NOTAMs)) that is available prior to the beginning of the flight. Tactical geofencing, the provision of updated information during the flight, will be available later as an initial service of U-space (U2).¹⁰⁷ The focus of initial services is especially on controlling the trajectories of unmanned air traffic. This second phase is envisioned as including flight planning, flight approval, tracking, dynamic airspace information, and interfaces with ATC.¹⁰⁸

Conducting operations in the second phase of U-space will be somewhat akin to flying in controlled airspace: the operator will have to consider flight conditions and other relevant information, such as NOTAMs, and submit a flight plan. However, again combining law and emerging technology, the operator will have digital single-source access to all the relevant data: aeronautical information service (AIS), weather, density of traffic, and conditions of the route. Authorities might not need to approve each flight separately, since an operation could automatically be permitted or denied, taking into account the flight plan, the parameters of other flight plans, and applicable regulations. Changes to the flight path will be done similarly, not requiring a controller to approve every move. The system will track each drone with the aid of surveillance systems, which will enable more operations beyond the visual line of sight (BVLOS). Data can flow between the operator and ATC in controlled airspace and emergency alerts can be transmitted.¹⁰⁹

To some extent, the initial services of U-space are already available through private companies. Some UTM solutions for ANSPs include a flight engine and a traffic engine that promise to allow ATC to notify and authorize drone operators, and to coordinate air traffic in real time.¹¹⁰ Such applications include tools by which the user can plan a flight path and receive a compliance brief about rules that the user may be violating. Flight plan submission, digital notices, and authorization are also available for some drones, and so is real-time status feedback and traffic alerts, using the same data that ATC uses.¹¹¹

In fact, the performance of current technology has been shown to be quite impressive. In September 2017, several industry partners conducted three missions in Geneva, demonstrating fundamental and initial services such as electronic identification, geofencing, and flight planning and tracking.¹¹² This sparked a partnership

¹⁰⁷ Drone Roadmap, *supra* n. 17, at 26.

¹⁰⁸ U-space Blueprint, *supra* n. 16, at 5 and 7. *See also* Drone Roadmap, *supra* n. 17, at 11 and 26–27; NPA 2017–05 (B), *supra* n. 14, at 42.

¹⁰⁹ U-space Blueprint, *supra* n. 16, at 5 and 7. *See also* Drone Roadmap, *supra* n. 17, at 11 and 26–27.

¹¹⁰ *See* Out-of-the-Box UTM, <https://www.airmap.com/utm/> (accessed 14 Aug. 2018).

¹¹¹ *See* AirMap for Drones, <https://www.airmap.com/airmap-for-drones/#> (accessed 14 Aug. 2018). A similar information rich tool for commercial operators to plan their flights is offered by Skyward. *See* Commercial Drone Software, <https://skyward.io/commercial-drone-software/> (accessed 14 Aug. 2018).

¹¹² Swiss U-space demonstrator run-through, <https://www.youtube.com/watch?v=Djjrrs703N0> (accessed 15 Aug. 2018).

between the undertaking and skyguide, the Swiss ANSP, to develop a nation-wide U-space in Switzerland. The capability of this partnership was demonstrated in June 2018, wherein dozens of drones conducted various commercial operations across the country. The drones could receive live airspace data, but also submit data about their own positioning and flight path, enabling separation.¹¹³

Although promising, current technological solutions do not mean that U-space could be implemented right away. This is chiefly because controlled demonstrations are one thing and live performance another.¹¹⁴ The reliability, capacity, and security of U-space can only be tested when an attempt is made to embed all drone operators into the system, representing the wide sphere of unmanned civil aviation. This requires that all drone models (over the aforementioned threshold of impact energy) have the capability to interface with U-space services, which necessitates technical standardization involving many stakeholders. Furthermore, U-space must have sufficient capacity to deal with all drones as well as safeguards to protect the services and aircraft from unlawful interference. Additional infrastructure¹¹⁵ has to be built to monitor traffic in urban areas, and of course some problems may only surface when the whole European airspace is provided with the services. Simply put, it remains unseen when UTM technology can meet the safety standards of the aviation industry.¹¹⁶

4.4 ADVANCED AND FULL SERVICES

The given observations strike even truer when it comes to the advanced services of U-space (U3). In U3, the lack of avoidance capability due to there being no pilot on board the UA will be compensated with automatic detect and avoid (DAA) functionalities. Being able to avoid unexpected hazards during the flight, including both physical obstacles and other drones, the drone will not have to know all possible obstacles beforehand. This will be combined with dynamic geofencing, which means that aerial restrictions will target the drone itself, not requiring input from the pilot. The capacity of a particular volume of airspace will be managed so that drones will be allocated slots

¹¹³ Swiss U-space Services Power Traffic Management for Dozens of Drone Flights in National Demo, <https://www.prnewswire.com/news-releases/swiss-u-space-services-power-traffic-management-for-dozens-of-drone-flights-in-national-demo-300672025.html> (accessed 15 Aug. 2018).

¹¹⁴ As an AirMap employee himself has noted, '[o]ne-day demonstrations ... need ... to transition into long-term pilot programs'. Jeremiah Karpowicz, *An Update on Drone Regulation and U-space Integration in Europe*, <https://www.expouav.com/news/latest/update-drone-regulation-u-space-integration-europe/> (accessed 15 Aug. 2018).

¹¹⁵ See e.g. Eric Adams, *Raytheon's New Radar Could Help Bring Flying Cars to Our Cities*, <https://www.wired.com/story/raytheon-radar-drones/> (accessed 12 July. 2018).

¹¹⁶ See EASA Annual Safety Review 2018 (EASA 2018); IATA Safety Report 2017 (IATA 2018); ICAO Safety Report 2017 (ICAO 2018).

depending on the amount of traffic. U3 will also provide more reliable means of communication. In particular, operators will be able to communicate with ATC when flying their drone in controlled airspace.¹¹⁷

The pinnacle of the U-space concept is called full services (U4). This signifies complete integration with manned air traffic and all services provided in airspace. Full services will take full advantage of the operational capacity of airspace, and utilize a very high level of automation, connectivity, and digitalization. It might also involve certifying manned aircraft with new equipment so that they could interface with UAS.¹¹⁸ All of this seems very vague, but for a good reason. Obviously, how the full integration of drones into the aviation framework will come to be is very unclear at this early stage, since not even the fundamental services of U-space have been comprehensively implemented. What EASA thus means by a very high level of automation, connectivity, and digitalization, remains to be seen.

Most of the aforementioned U-space services require the drone to be equipped with certain technical capabilities. Yet the idea is not to subject all drones to traditional airworthiness certification to ensure that such capabilities are met. Only drones falling within the certified category must obtain a type certificate and a CofA. In the specific category, such requirements will be handled through the operation authorization process. For drones in the open category, covering most of the current market, technical requirements will be established through product legislation (CE marking) rather than aviation law.¹¹⁹ The latter approach means that only drones that follow certain standards will be allowed to be sold as consumer products within the European Union.¹²⁰ U-space will therefore, in a way, extend beyond the borders of the Union into states where UAS are manufactured.

5 CONCLUSIONS

Unmanned aircraft systems, or drones, are in many ways unique aircraft that have not been easy to integrate into the established framework of air law. The design of the legal framework is inappropriate for drones in numerous ways, as described above. It burdens both aircraft and their operators with numerous obligations that drones have difficulty in complying with. Likewise, flight rules are designed for

¹¹⁷ U-space Blueprint, *supra* n. 16, at 5 and 7–8. See also Drone Roadmap, *supra* n. 17, at 28–29; NPA 2017-05 (B), *supra* n. 14, at 42.

¹¹⁸ U-space Blueprint, *supra* n. 16, at 5 and 7–8. See also Drone Roadmap, *supra* n. 17, at 28; NPA 2017-05 (B), *supra* n. 14, at 42.

¹¹⁹ See A-NPA 2015-10, *supra* n. 87.

¹²⁰ See Draft Regulation on market, *supra* n. 19.

manned aviation rather than unmanned operations in VLL airspace, or BVLOS operations. These challenges must be met if the air traffic of drones is to be managed in a safe and efficient manner.

The European U-space concept provides a solution on two fronts. On one hand, it consists of regulatory requirements and practices, calling for registration, identification, and flight planning. Most elements of the concept have a legal core (whether as binding obligations or recommendations), including for example the restriction of access to certain designated zones, and the requirement to use aeronautical information services to maintain situational awareness. On the other hand, U-space is all about new technological solutions, like electronic and inter-operable registration, identification, and geofencing. Further on, even more high-tech means are meant to ensure the safety of the operation in dense traffic. Such solutions will include electronic flight planning, tracking, automated detect and avoid, and integration with the systems of manned aviation. U-space is therefore characterized by an interplay between law and emerging technology, which makes sense. One cannot draft legal standards without taking into account technological developments, and the development of technology equally depends on regulatory necessities.

U-space is also characterized by an interplay between the public and the private sectors. On one hand, the concept is a project of European regulatory bodies and national authorities for purposes of public safety, security, and economic growth. Yet it is obviously impossible to establish U-space services independently of the private companies that produce and use drones, or develop UTM services. Thus, it is no wonder that the current vision of U-space is a diplomatic offering, representing the interests of various stakeholders. Pilots of manned aircraft will be satisfied that drones will be identifiable and their flights more controlled; air traffic controllers will find comfort in the fact that automation will prevent their workload from expanding; and drone operators will be pleased that they will be offered high end tools to plan operations. Increased safety will, meanwhile, be favourable to all parties as well as the general public. U-space will especially offer utility when it comes to operating drones in an urban environment, which is to be expected. After all, most challenges presented above are exacerbated in urban airspace.

Since legal standards and technology are being developed simultaneously by public and private bodies, many U-space services are already available today. Drones are being electronically registered in some states, and many contemporary models use geofencing and intelligent flight modes. Furthermore, several international companies offer solutions that represent the first two phases of U-space. AirMap, Skyward, and Unifly are three service providers that, to varying degrees, help operators plan their flights in accordance with aviation regulations. The first of

the three has already, with skyguide, demonstrated the possibility of unmanned traffic management in Swiss airspace. Considering the success of these demonstrations, U-space will without a doubt at some point be realized.

Yet, the current U-space capabilities of such solutions are fragmentary: there is no uniform system across any nation, let alone the whole of Europe. Indeed, it is still unclear how many and which stakeholders will be involved in providing U-space services. Will there be a single U-space service provider or several of them within a particular state or a segment of its airspace? What about the airspace not falling under the sovereignty of any state? Will U-space be provided by ANSPs or other entities? Which parties should bear liability for incidents? Questions like these highlight the complexity of the project, especially in the long run.

Another issue is that current U-space solutions have only been tested in controlled environments rather than in live conditions. Whether they will be able to handle the growing drone traffic in terms of both quantity and quality thus remains to be seen. This will require the system to demonstrate sufficient capacity, reliability, and security: all parties must be able to trust in the information that flows across the various platforms. Additional investments in workforce and infrastructure will likely be necessary. Meanwhile, drones themselves (excluding the ones falling below the impact energy threshold) must be standardized so that they are able to communicate with the systems. U3 and U4 services, like automatic DAA capability, dynamic geofencing, capacity management, and ultimately full integration with manned aviation, are still a distant prospect.

These challenges naturally beg the question: ‘When?’. When will U-space be realized to its full extent? According to SESAR’s Drone Roadmap, at the earliest, U1 services will be available in 2019, U2 services in 2022, U3 services in 2027, and U4 services in 2035.¹²¹ Taking into account that certain U1 services are already available at the time of writing this article (autumn of 2018), the first goal appears rather realistic. However, a reasonable caveat is that by the end of 2019 U-space, including fundamental services like electronic registration, will still remain fragmentary across the EU. As for U2 services and beyond, the target years are mere estimates. The reason for this can be summarized in one word: safety. In the end, the key issue may not be whether such services can be delivered on time, but whether they can be provided with sufficient safeguards to satisfy the demands of civil aviation. The interest of all stakeholders is to ensure that no person nor aircraft is endangered due to false or incomplete data being transmitted across U-space.

¹²¹ Drone Roadmap, *supra* n. 17, at 12.

